Goddard

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO
ATTN OF: GP

TO: KSI/Scientific & Technical Information Division
Attn: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General
Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code KSI, the attached NASA-owned U.S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No.	: 3,803,617
Government or Corporate Employee	: 42 USC 2457 Hughes Aircraft Co. LA, CA
Supplementary Corporate Source (if applicable)	:
NASA Patent Case No.	: GSC-11373

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

YES [X] NO [ ]

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of column No. 1 of the Specification, following the words "...with respect to an invention of ..."

Bonnie L. Woerner

Bonnie L. Woerner
Enclosure

United States Patent [19]

Fletcher et al.

[11] **3,803,617**

[45] **Apr. 9, 1974**

[54] **HIGH EFFICIENCY MULTIFREQUENCY FEED**

[76] Inventors: **James C. Fletcher**, Administrator of the National Aeronautics and Space Administration, with respect to an invention of; **James S. Ajioka**; **George I. Tsuda**, both of Fullerton; **William A. Leeper**, Anaheim, all of Calif.

[22] Filed: **Apr. 14, 1972**

[21] Appl. No.: **244,158**

[52] **U.S. Cl.** **343/730**, 343/786, 343/797, 343/853

[51] **Int. Cl.** **H01q 1/00**

[58] **Field of Search** 343/729, 730, 786, 797, 343/853, 854

[56] **References Cited**

UNITED STATES PATENTS

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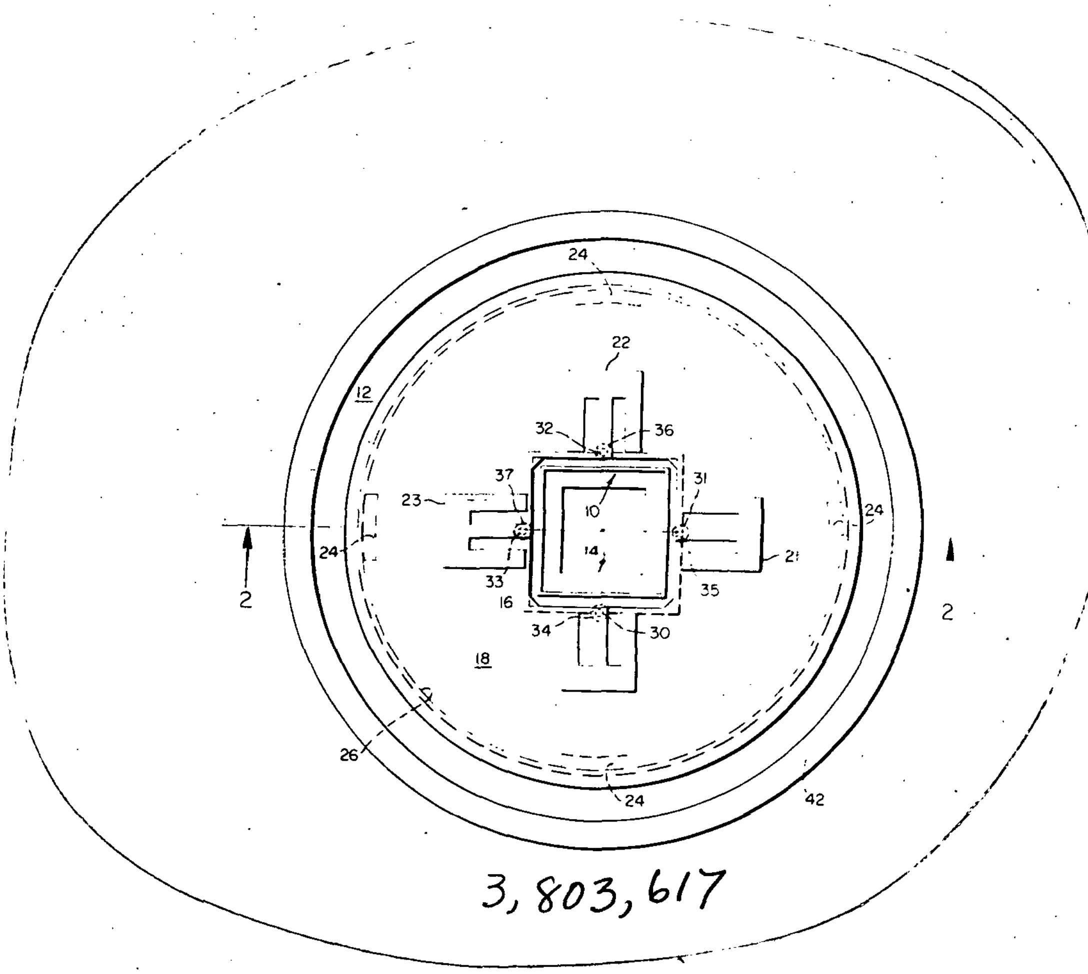
Primary Examiner—Eli Lieberman

Attorney, Agent, or Firm—Leonard Rawicz; Neil B. Siegel; Robert F. Kempf

[57] **ABSTRACT**

The apparatus of the present invention relates to antenna systems and particularly to compact and simple antenna feeds which can transmit and receive simultaneously in at least three frequency bands, each with high efficiency and polarization diversity. The feed system is especially applicable for frequency bands having nominal frequency bands with the ratio 1:4:6. By way of example, satellite communications telemetry bands operate in frequency bands 0.8 – 1.0 GHz, 3.7 – 4.2 GHz and 5.9 – 6.4 GHz. In addition, the antenna system of the invention has monopulse capability for reception with circular or diverse polarization at frequency band 1.

14 Claims, 12 Drawing Figures



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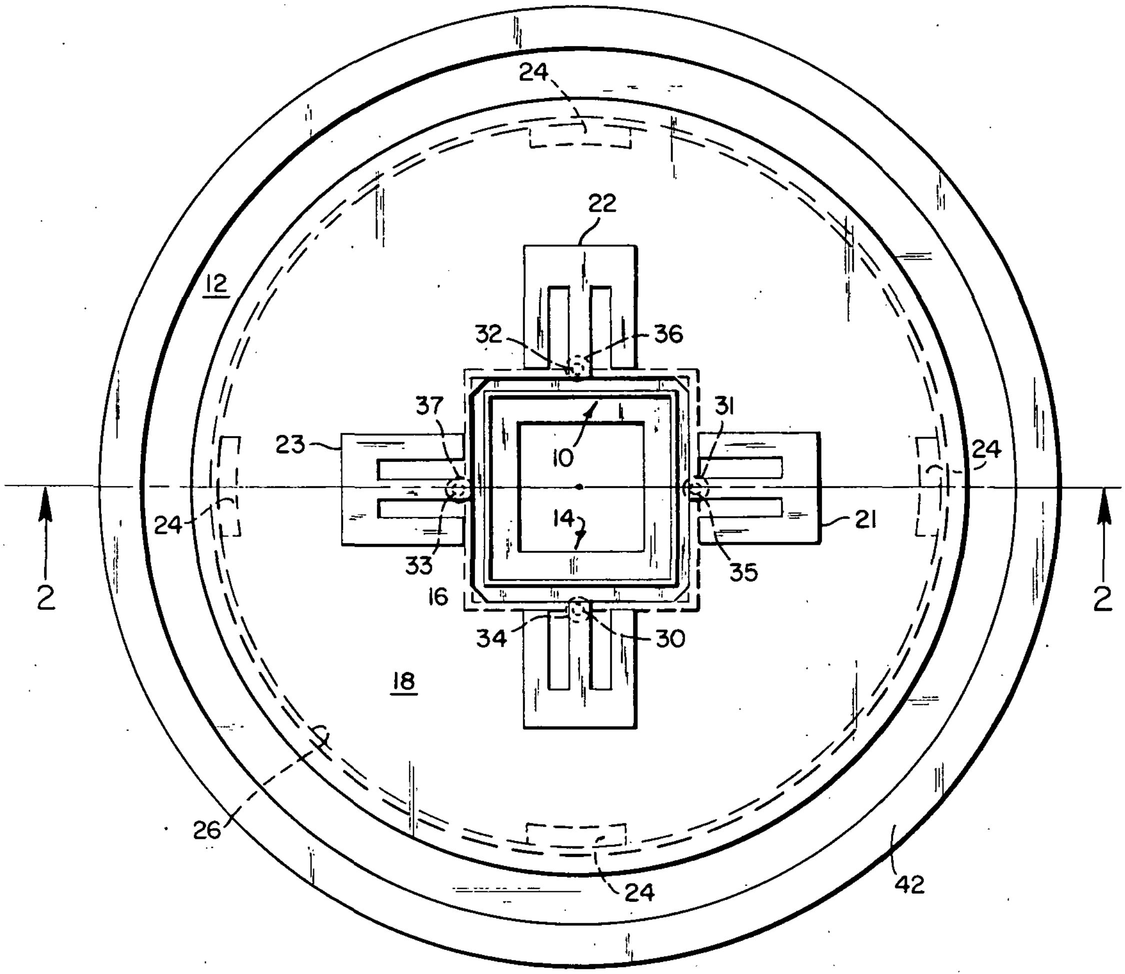


Fig. 1

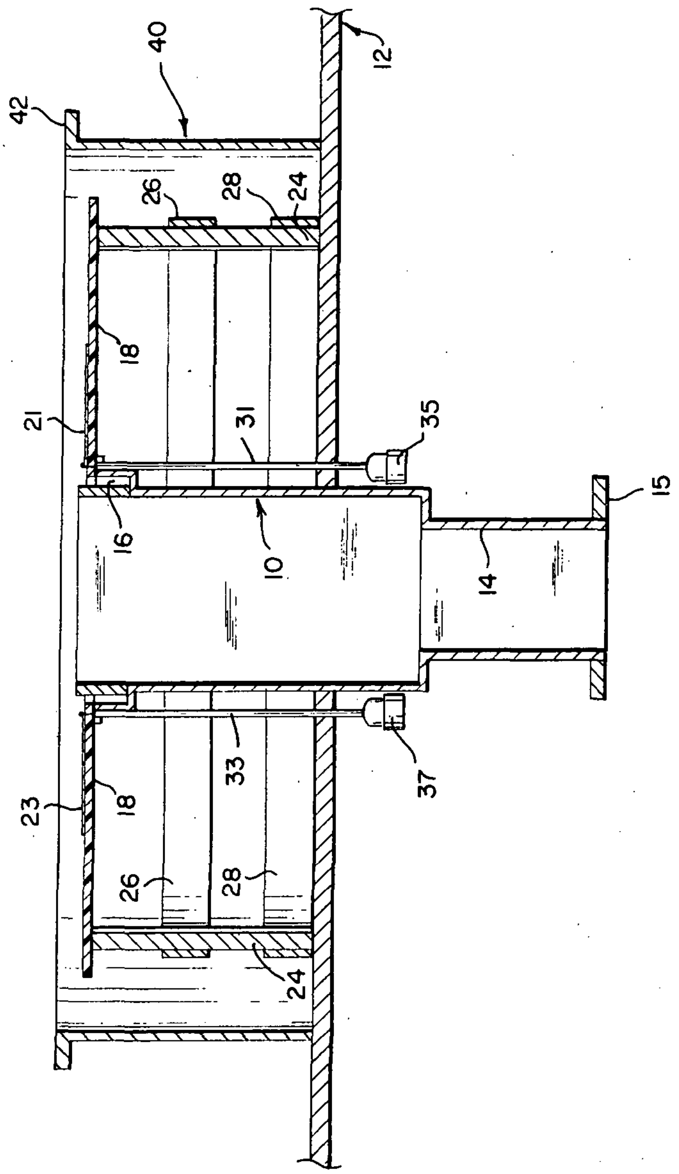


Fig. 2

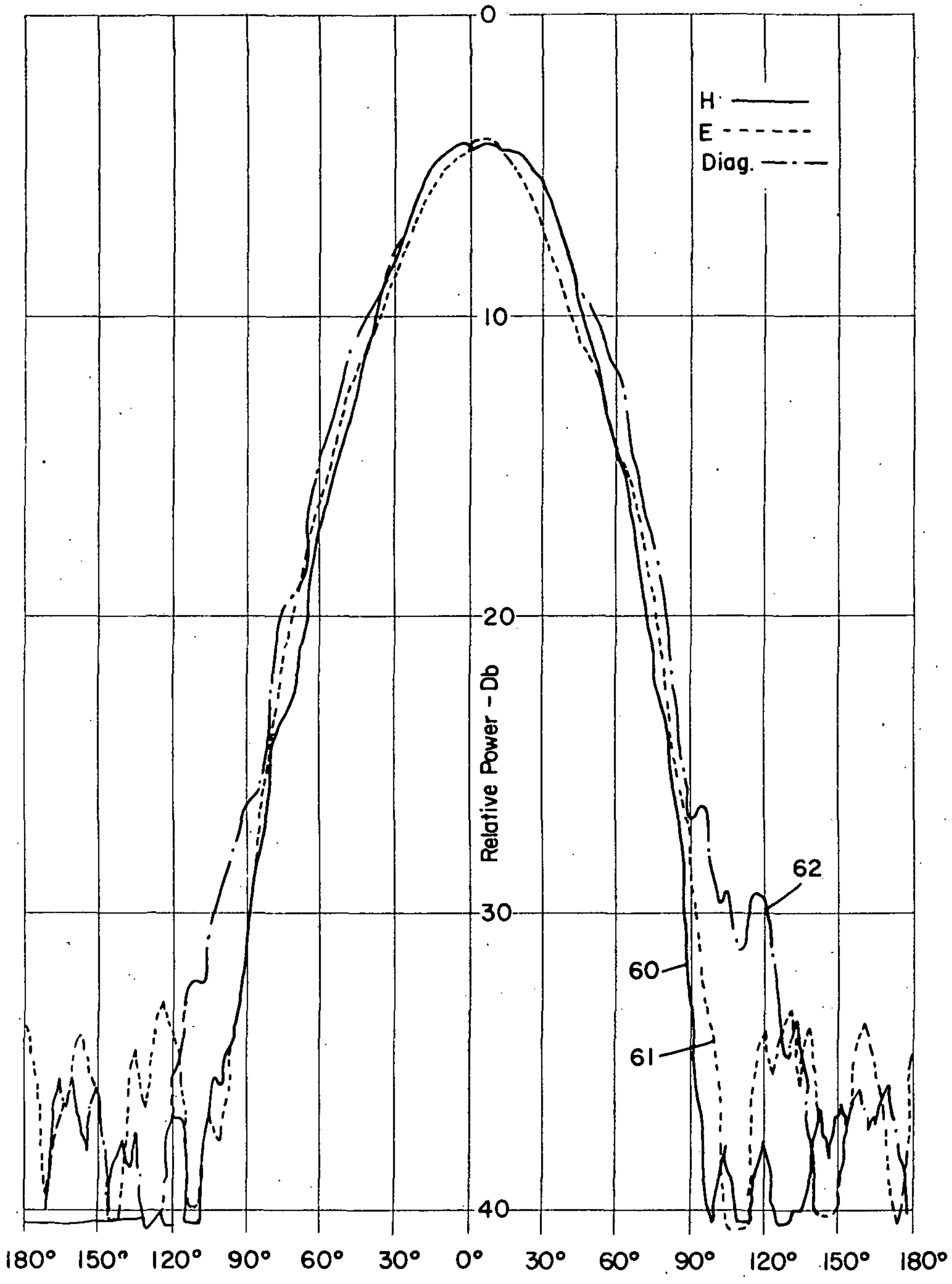
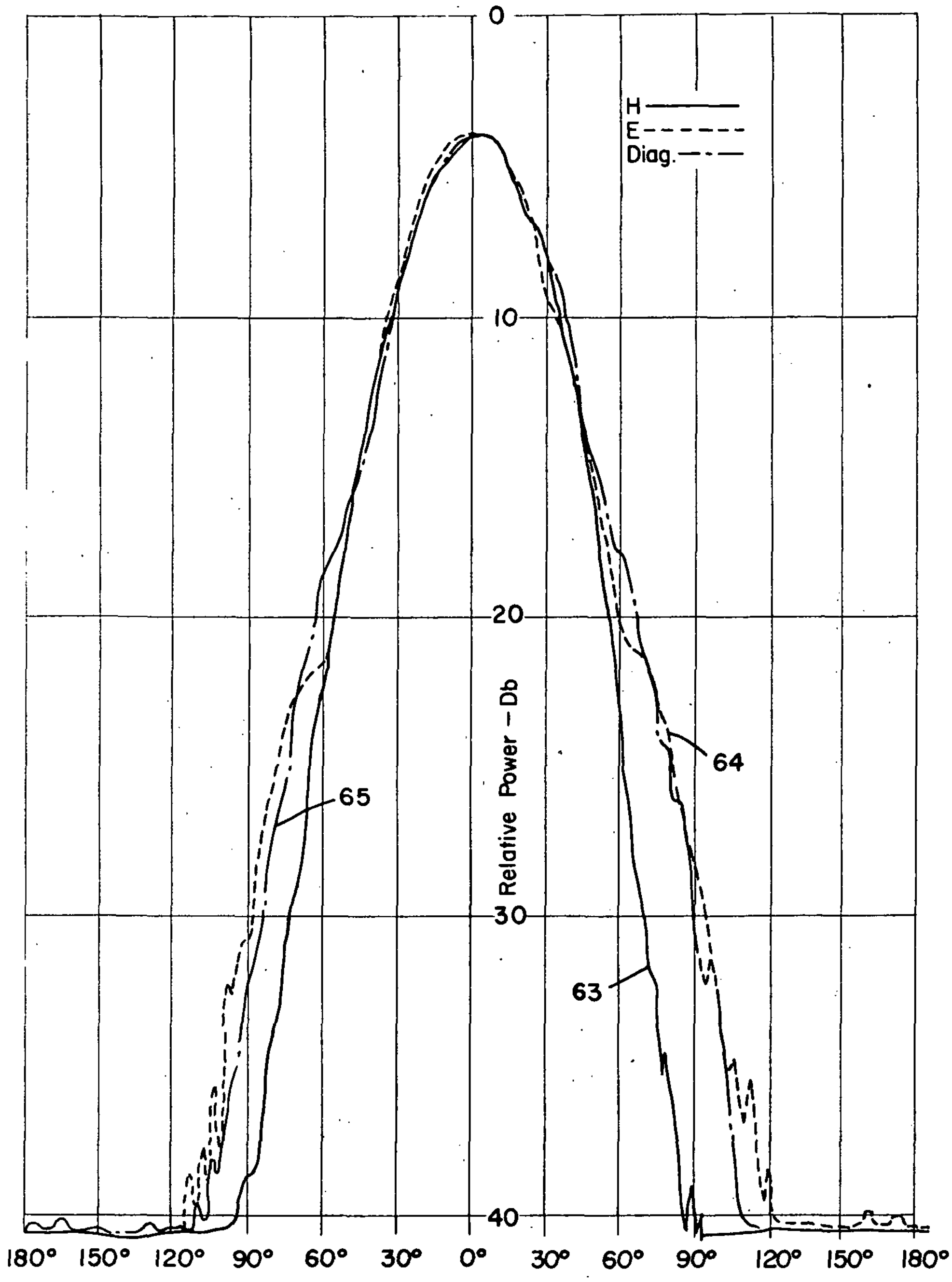

H
E
Diag.
0
10
20
30
40
Relative Power - Db
60
61
62
180°
150°
120°
90°
60°
30°
0°
30°
60°
90°
120°
150°
180°

Fig. 3.


H
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Diag.
0
10
20
30
40
Relative Power – Db
63
64
65
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150°
120°
90°
60°
30°
0°
30°
60°
90°
120°
150°
180°

Fig. 4.

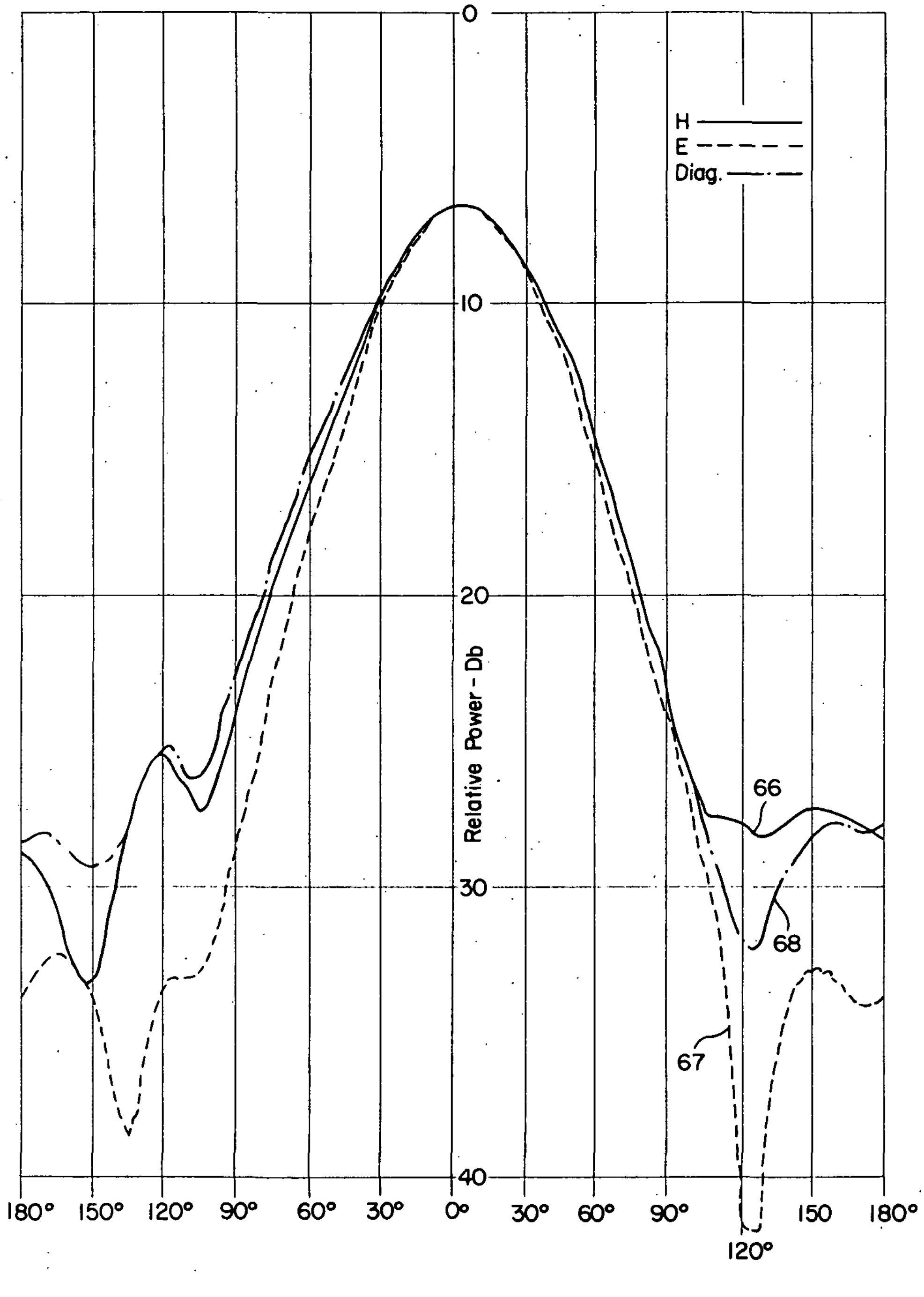

H
E
Diag.
0
10
20
30
40
Relative Power - Db
66
67
68
180° 150° 120° 90° 60° 30° 0° 30° 60° 90° 120° 150 180°

Fig.5.

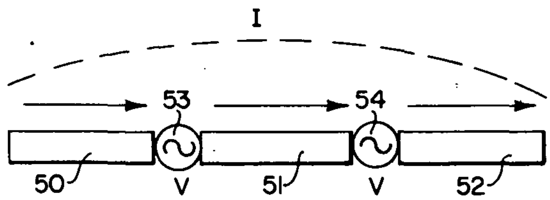


Fig. 6.

Two Point Fed Dipole Model
Showing Current Distribution

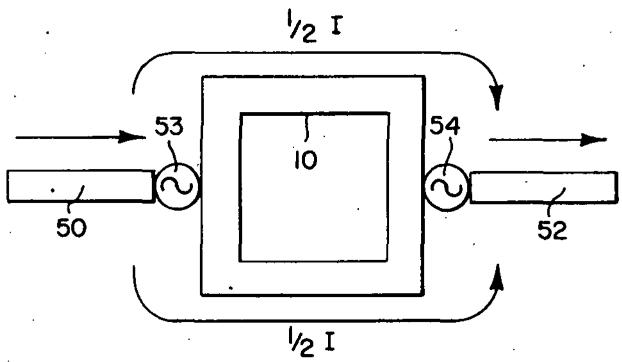


Fig. 7.

Higher Frequency Horn Feed Serves As
Central Portion Of Two Point Fed Dipole

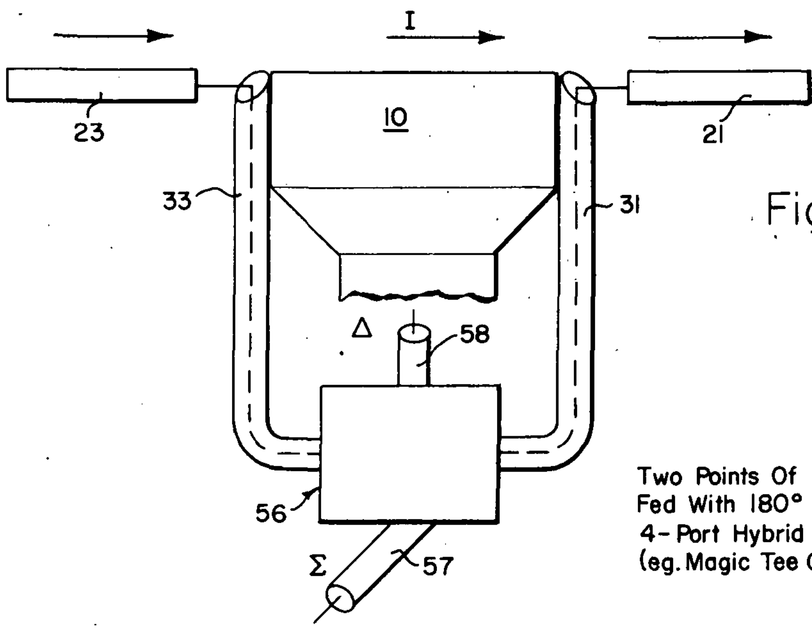


Fig. 8.

Two Points Of Dipole
Fed With 180°
4-Port Hybrid
(eg. Magic Tee Or Ratrace)

Diagram Showing High Freq. Horn As Part Of Low Freq. Dipole

Fig. 9.

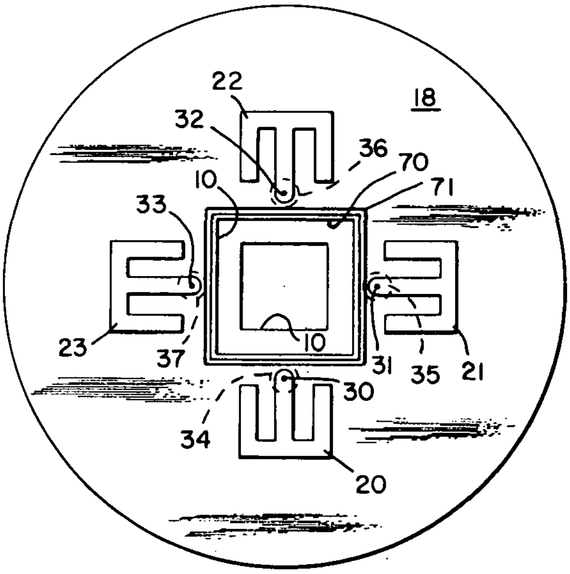


Fig. 10.

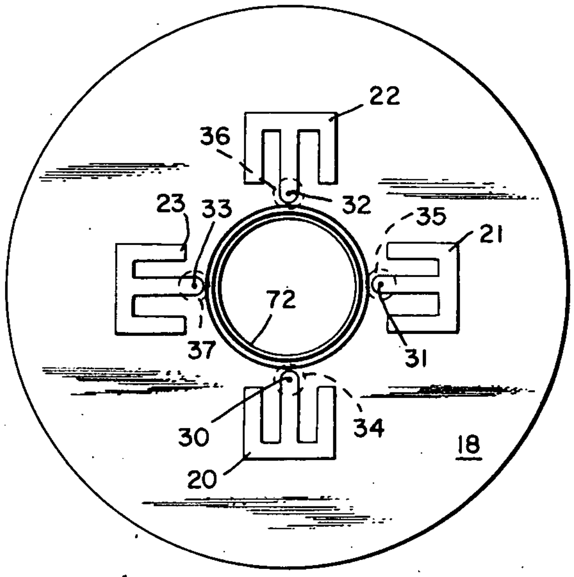


Fig. 11.

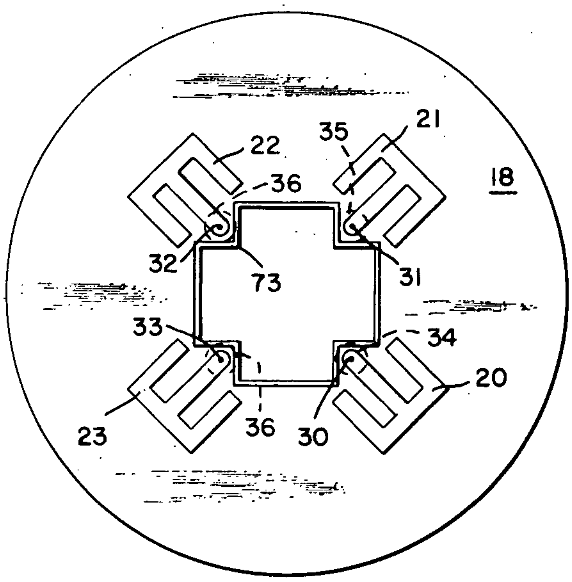
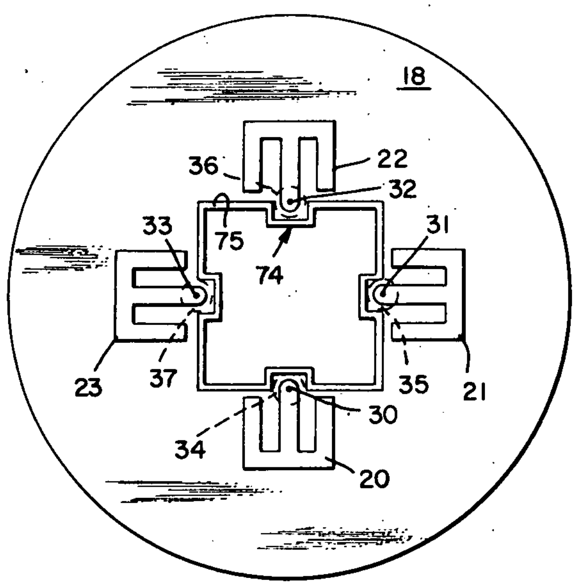


Fig. 12.



HIGH EFFICIENCY MULTIFREQUENCY FEED

BACKGROUND OF THE INVENTION

Conventional techniques comprise the use of nested horns or nested dipole clusters. In the case of nested horns, a high frequency horn is nested inside an intermediate frequency horn which, in turn is nested inside a low frequency horn. This system generally has low efficiency because of the mutual aperture blockage effects. In the case of the nested dipole clusters, a high frequency quaddipole array is nested within an intermediate frequency quad-dipole array which, in turn, is nested within a low frequency quad-dipole array. Nested dipole clusters of this type generally have low efficiency due to mutual coupling effects.

SUMMARY OF THE INVENTION

The present invention circumvents the problems of mutual blockage and mutual coupling by using a single common aperture for the 6 and 4 GHz frequency bands and a crossed dipole for the 1 GHz frequency band. The crossed dipole is not a conventional dipole in that each dipole is excited at two points with edges of a 6/4 GHz horn as the central portion of the dipole. To achieve a high efficiency, the primary pattern of the feed must illuminate the reflector or lens without an undue amount of "spillover" or without being too directive so as to under illuminate the reflector or lens. The net result is that the feed pattern for all three frequency bands must be nearly identical in all planes and have a common center of phase. This is achieved in the 6/4 GHz common horn by multimoding at 6 GHz so that its effective aperture is less (about three-fourths linear dimension) than the physical aperture of the 6/4 GHz horn while at the 4 GHz frequency it is not multimoded so that it has its full physical aperture. This results in the 6 GHz and 4 GHz frequency bands having similar feed patterns for proper reflector or lens illumination. A crossed set of two 2-point feed strip dipoles are used for the 1 GHz frequency band.

One or more quarter wave chokes surrounding the 6/4 GHz horn aperture prevent coupling to the 1 GHz frequency wave dipole. Also, a choke is built into the dipole wings to further prevent coupling with 4 GHz frequencies. The 6 GHz frequencies are sufficiently far removed from the 1 GHz frequency band so that the coupling to the 1 GHz dipole is sufficiently suppressed by the choke around the horn alone. Separation between the 6 GHz and 4 GHz frequencies is achieved with conventional diplexers. Lastly, the two feed points of the dual feedpoint dipole are connected with a hybrid (e.g., a magic tee). When the difference port is used, the currents in the dipole wings are in phase resulting in a good "sum" pattern. When the "sum" port of the hybrid is used, the currents in the dipole wings are in anti-phase creating a null pattern. Hence, for certain polarizations, the sum port of the hybrid can be used for monopulse tracking applications. This type of tracking is especially applicable in circularly polarized systems.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a plan view of a C band - UHF aperture of a high efficiency multifrequency feed in accordance with the present invention;

FIG. 2 shows a cross-sectional view of the C Band - UHF aperture of FIG. 1;

FIGS. 3–5 illustrate the feed patterns for the H, E and diagonal planes for each of the frequency bands of the apparatus of FIGS. 1 and 2;

FIG. 6 illustrates a schematic of a two point fed dipole model showing current distribution;

FIG. 7 illustrates a schematic showing the manner in which a higher frequency horn feed serves as a central portion of the two point fed dipole in the illustration of FIG. 6;

FIG. 8 illustrates the manner in which the two point fed dipole of FIG. 7 is fed by the use of a 180° 4-Pont Hybrid; and

FIGS. 9–12 show alternative configurations of the plan view of the aperture of the multifrequency feed of FIGS. 1 and 2.

DESCRIPTION

Referring to FIGS. 1 and 2 of the drawings, there is shown a plan view of the aperture and a cross-section 2—2 thereof, respectively, of the high efficiency multifrequency feed antenna system of the present invention. In particular, a square horn **10** having dimensions suitable to provide a 6 GHz and 4 GHz common aperture extends through the central portion of a conductive ground plane **12.** On the back side of ground plane **12** relative to the antenna aperture, the square horn **10** extends into a multimode step section **14** dimensioned for 6 GHz which section **14** terminates in a flange **15.** The multimode step section **14** is symmetrically disposed about the center line through horn **10.** Surrounding the outer periphery of horn **10** at the lip thereof is disposed a choke section **16** primarily designed to inhibit the flow of 4 GHz energy thereacross.

Relative to the 1 GHz frequency band, a dielectric disc **18** extends radialy outwards from the outer lip of choke section **16** for a sufficient distance to support UHF choked dipole arms **20, 21, 22** and **23** which extend outwards from the center of the four sides of horn **10.** The outer periphery of dielectric disc **18** is supported by metallic posts **24** which extend to the ground plane **12.** A UHF cavity is formed by metal bands **26, 28** disposed about the central portion and adjacent ground plane **12,** respectively, of the metallic posts **24.** The extremity of the center leg of the UHF choked dipole arms **20–23** nearest horn **10** are fed by the respective center conductors of coaxial lines **30–33,** respectively. The coaxial lines **30–33** extend through the ground plane **12** parallel to the center line of horn **10** and are terminated by connectors **34–37,** respectively. The outer conductors of coaxial lines **30–33** are electrically connected to the outer periphery of choke section **16** and to the ground plane **12.** Lastly, a metal cylinder **40** terminating in a flange **42** is disposed symmetrically about metallic posts **24.** Metal cylinder **40** is attached to ground plane **12** and has a height slightly greater than the dimension of square horn **10** which extends through the ground plane **12.** The flange **42** provides a support for a radome if desired.

In the operation of the multifrequency prime focus feed of the present invention, the 4 GHz and 6 GHz frequency band signals are fed through the multimode step section **14** to the horn **10.** Contemporary multimoding techniques are employed to obtain the multimoding at the 6 GHz frequency band and single moding at the 4 GHz frequency band. In particular, the mode exciters coupled to flange **15** are designed for both the 4 GHz and 6 GHz frequency bands and the common

aperture of horn **10** is dimensioned to be below cutoff for the higher modes at 4 GHz. The separation of the 4 GHz and 6 GHz frequency bands is achieved with conventional diplexers, not shown. Quarter wave choke **16** surrounding the 6/4 GHz horn **10** aperture prevents coupling from the 4 GHz and 6 GHz frequency bands to the 1 GHz frequency dipoles **20–23**. Also, there is a choke built into each of the dipoles **20-23** to further prevent coupling with the 4 GHz frequencies. The 6 GHz frequencies are sufficiently far removed that coupling to the 4 GHz dipoles **20–23** is sufficiently suppressed by the choke **16** around the horn **10** alone.

Referring to FIGS. **6–8**, there is illustrated the manner in which opposite dipoles **20, 22** and **21, 23** operate. In particular, FIG. **6** illustrates a two point fed dipole having segments **50, 51**, and **52** driven by voltage sources **53, 54** which supply a signal voltage, V. When voltage sources **53, 54** drive the dipole segments **50, 51, 52** in phase, the current, I, increases from the left extremity, as shown in the drawing, to a maximum along center segment **51** and then decreases to zero at the right extremity of segment **52**. This current distribution is similar to that of a typical dipole, with the exception that it is fed at two points instead of one.

Proceeding to FIG. **7**, the center segment **51** of FIG. **6** is replaced with the horn **10**. In this case, the current that previously flowed through the center segment **51** divides and flows around opposite sides of the horn **10**.

Lastly, FIG. **8** shows the dipoles **50, 52** replaced with the choked dipoles **23, 21**, respectively, and the voltage sources **53, 54** provided by coaxial lines **33, 31**, as in FIG. **1**. The coaxial lines **31, 33** are, in turn, fed with a 180° four-port hybrid **56**. When fed through a sum input (Σ) **57** thereof, the voltages at the outputs of coaxial lines **31, 33** are in anti-phase, creating a null pattern. Alternatively, when fed through the difference input (Δ) **58**, the voltages at the outputs of coaxial lines **31, 33** are in phase, resulting in a good "sum" pattern. Hence, for a particular polarization, the sum and null patterns can be used for monopulse tracking applications. Lastly, in a normal mode of operation, the remaining dipoles **20, 22** are fed in phase with a hybrid (not shown) which, in turn, may be fed 90° out of phase relative to the signal applied to hybrid **56**, thereby to generate a circularly polarized output signal.

In the multifrequency antenna feed system it is desirable that the feed pattern for each of the three frequency bands be nearly identical in all planes and have a common center of phase. In the 6/4 common horn **10** this is achieved by multimoding at 6 GHz so that its effective aperture is less by about three-fourths linear dimension than the physical aperture of the 6/4 GHz horn **10**, while at the 4 GHz frequency it is not multimoded so that it has its full physical aperture. This results in the 6 GHz and 4 GHz frequency bands having similar feed patterns for proper reflector or lens illumination. The horn-dipole assembly is contained in a 1 GHz cavity formed by ground plane **18**, and the metal bands **26, 28** whose parameters are adjusted to shape the 1 GHz patterns without affecting the 6 and 4 GHz patterns.

Referring to FIGS. **3–5**, there is illustrated measured horizontal, vertical, and diagonal patterns for the 4 GHz, 6 GHz, and 1 GHz frequency bands developed by the antenna system of FIGS. **1** and **2**, respectively. In particular, FIG. **3** illustrates a horizontal pattern **60**, a vertical pattern **61**, and a diagonal pattern **62** for the 4 GHz frequency band; FIG. **4** illustrates a horizontal pattern **63**, a vertical pattern **64**, and a diagonal pattern **68** for the 1 GHz frequency band. As can be seen from these figures, the feed patterns of the antenna system of FIGS. **1** and **2** is nearly identical in all planes for each of the three frequency bands, as is required for antenna feeds of this type. Although the described embodiment of the invention was designed for the 3.7 – 4.2 GHz band, the 5.9 – 6.4 GHz band and the 0.8 – 1 GHz band, the principles embodied therein are applicable to other frequency bands.

Referring to FIGS. **9–12**, there are illustrated other possible configurations of the multifrequency feed. More particularly, FIG. **9** shows an aperture view with double choke slots **70, 71** surrounding the periphery of horn **10**. Choke slot **70**, for example, could be designed to impede the 4 GHz frequency band and choke slot **71** designed to impede the 6 GHz frequency band. Referring to FIGS. **10, 11**, a circular horn **72** and a crossed-horn **73** are shown, respectively, in place of the square horn **10**. In the case of the crossed-horn **73**, the choked dipole arms **20-23** emanate from the inside corners thereof. Lastly, FIG. **12** illustrates a horn **74** having indentations adapted to accommodate coaxial lines **30–33**. A choke slot **75** about the periphery of the horn **74** follows the aforementioned indentations.

What is claimed is:

1. A high efficiency antenna feed system capable of transmitting and receiving simultaneously in first, second, and third increasingly higher frequency bands, said antenna feed system comprising

means including a horn for providing a common radiating aperture for signals within said second and third frequency bands;

means coupled to said horn for multimoding at said third frequency band therein;

means surrounding said horn for providing a cavity for said first frequency band;

first and second arms resonant in conjunction with said horn at said first frequency band and extending outwards from opposite sides of the periphery thereof; and

means coupled to the respective extremities of said arms nearest said horn for energizing said arms.

2. The high efficiency antenna feed system as defined in claim **1** additionally including means disposed about the periphery of said horn for isolating said first frequency band from said second and third frequency bands.

3. The high efficiency antenna feed system as defined in claim **2** wherein said means disposed about the periphery of said horn for isolating said first frequency band from said second and third frequency bands constitutes a slot formed of conductive material, said slot being one quarter wavelength deep at said second frequency band, thereby to provide a choke.

4. The high efficiency antenna feed system as defined in claim **2** wherein said means disposed about the periphery of said horn for isolating said first frequency band from said second and third frequency bands constitutes first and second parallel slots formed of conductive material, said first slot being one quarter wavelength deep at said second frequency band and said second slot being one quarter wavelength deep at said

third frequency band, thereby to provide first and second chokes at said second and third frequency bands, respectively.

5. The high efficiency antenna feed system as defined in claim 1 wherein said first and second arms extending outwards from opposite sides of the periphery of said horn are choked thereby to isolate said first frequency band from said second frequency band.

6. The high efficiency antenna feed system as defined in claim 1 additionally including third and fourth arms resonant in conjunction with said horn at said first frequency band and extending outwards from opposite sides of the periphery thereof midway between said first and second arms.

7. The high efficiency antenna feed system as defined in claim 6 wherein said first, second, third, and fourth arms extending outwards from the periphery of said horn are choked thereby to isolate said first frequency band from said second frequency band.

8. The high efficiency antenna feed system as defined in claim 7 wherein said means surrounding said horn for providing a cavity for said first frequency band includes means for providing a ground plane outwards from the exterior of the rear portion of said horn normal to the axis of rotation thereof, a plurality of metallic posts disposed intermediate said ground plane and the plane of said first, second, third, and fourth arms at periodic intervals along the circumference of a circle of predetermined radius and having a center coinciding with the axis of rotation of said horn, and first and second parallel metallic bands disposed about said plurality of metallic posts.

9. The high efficiency antenna feed system as defined in claim 1 wherein said first and second arms extending outwards from opposite sides of the periphery of said horn are connected to first and second arms, respectively, of a four-part hybrid junction, having said first and second arms, a sum arm, and a difference arm.

10. The high efficiency antenna feed system as defined in claim 1 wherein the cross-sectional configuration of said horn is square.

11. The high efficiency antenna feed system as defined in claim 1 wherein the cross-sectional configuration of said horn is circular.

12. The high efficiency antenna feed system as defined in claim 1 wherein the cross-sectional configuration of said horn constitutes the outer configuration of first and second crossed identical rectangles.

13. The high efficiency antenna feed system as defined in claim 1 wherein the cross-sectional configuration of said horn is square with indentations in the center portions of each side thereof.

14. A high efficiency antenna feed system capable of transmitting and receiving simultaneously in first, second, and third increasingly higher frequency bands, said antenna feed system comprising

a ground plane;

a horn disposed through said ground plane for providing a common radiating aperture for signals within said second and third frequency bands;

a step section connected to the input of said horn for multimoding at said third frequency band therein;

first, second, third, and fourth arms resonant in conjunction with said horn at said first frequency band extending outwards from quadrature points of the periphery thereof;

a plurality of metallic posts extending between said ground plane and the plane of said first, second, third, and fourth arms along the circumference of a circle disposed about said horn;

first and second parallel metallic bands disposed about said plurality of metallic posts thereby to provide a cavity resonant at said first frequency band; and

means coupled to the respective extremities of said first, second, third, and fourth arms nearest said horn for energizing said arms.

* * * * *